



NASA STTR 2016 Phase I Solicitation

T3 Space Power and Energy Storage

Space Power and Energy Storage is divided into four technology areas: power generation, energy storage, power management and distribution, and cross cutting technologies. NASA has many unique needs for space power and energy storage technologies that require special technology solutions due to extreme environmental conditions. These missions would all benefit from advanced technologies that provide more robust power systems with lower mass.

Subtopics

T3.01 Energy Transformation and Multifunctional Power Dissemination

Lead Center: SSC

Participating Center(s): GRC, JSC, KSC

The NRC has identified a NASA Top Technical Challenge as the need to "Increase Available Power". Additionally, a NASA Grand Challenge is "Affordable and Abundant Power" for NASA mission activities. As such, transforming and disseminating naturally occurring and artificially induced energy from multiple environments into usable power is critical toward supporting future power generation systems. This subtopic addresses the potential for deriving power from the environment for; local or remote consumption, inundating structures or environments with energy, transmission, distribution, regulation, and storage of said energies. Conversion and transformation technologies for gathering energy naturally occurring in conjunction with induced energies are being pursued, and novel technologies capable of artificially saturating an environment with energy for storage and power dissemination along with non-conventional transmission via the surrounding environments such as wireless power are also applicable. Energy gathering is limited by the quantity of energy available within a system's immediate environment, and often the environment's energy contains prolonged periods of lulls in harvestable energy. Technologically bridging power from a distance would fundamentally alleviate issues with low energy environments by allowing energy to be supplementally broadcast through preexisting structures and environments while simultaneously reducing docking and interfacing for power transfer. Technology development should support powering small remotely located equipment such as wireless instrumentation, or support power gathering for independently providing supplementary power to centralized equipment such as control consoles. Distributed Nano energy generating technologies are applicable for gathering scattered environmental energies into significant amounts of accumulated power along with supplementation for long-duration power utilization. This kind of distributed power should also be able to recover waste energy from rocket, nuclear, fission, and electrical propulsion devices while providing enhanced protection from energies contained within the work environment through transformation and consumption. Transforming harmful radiation, elevated temperatures, unwanted vibrations etc. into usable energy will support increased scope and duration of missions while enhancing protection from the waste energies (mitigation by transformation and consumption). Waste energies from warm soil, liquids (water, oils, hydraulic fluids), kinetic motion, piezoelectric materials, or various naturally occurring energy sources,

etc. should also be transformable.

Areas of special focus for this subtopic include consideration of:

- Innovative technologies for the efficient broadcast, capture, regulation, storage and/or transformation of acoustic, kinetic, radiant (including radiation), electric, magnetic, radio frequencies and thermal energy types.
- Technologies which can work either under typical ambient environments for the above energy types and/or under high intensity energy environments for the above energy types as might be found in propulsion testing and launch facilities.
- As above, energy capture, transmission and transformation technologies that can work in very harsh environments such as those which are very hot and/or ablative (e.g., in the proximity of rocket exhaust) and/or very cold (e.g., temperatures associated cryogenic propellants) may be of interest.
- Innovations in miniaturization and suitability for manufacturing of energy capture, transmission and transformation systems so as to be used towards eventual powering of assorted sensors and IT systems on vehicles and infrastructures.
- High efficiency and reliability for use in environments that may be remote and/or hazardous and having low maintenance requirements.
- Employ green technology considerations to minimize impact on the environment and other resource usage.

Rocket propulsion test facilities within NASA provide excellent test beds for testing and using the innovative technologies discussed above because they offer a wide spectrum of energy types and energy intensities for capture and transformation. Additional Federal mandates require the optimization of current energy use and development of alternative energy sources to conserve on energy and to enhance the sustainability of these and other facilities.

Specific emphasis is on technologies which can be demonstrated in a ground test environment and have the ability/intention to be extrapolated for in-space applications such as on space vehicles, platforms or habitats. Energy transformation technologies to generate higher power output than what is presently on the market are a highly desired to an expected outcome from this subtopic.

Phase I will develop feasibility studies and demonstrate through proof-of-concept demonstrations. Phase II will develop prototypical hardware and demonstrate infusion readiness to be incorporated into other products.

T3.02 Self-Powered, Ultra-Miniature Devices

Lead Center: MSFC

Participating Center(s): GSFC, SSC

As the Human Exploration and Operations (HEOMD) Mission Directorate seeks technologies in support of NASA space operations related to human exploration in Space, development of technologies that address efficient energy usage and storage are considered to be of utmost importance. Development of a range of self-powered devices that maximize the safety and reliability of extended missions can only enhance human space flight capabilities in support of human and robotic exploration programs.

Suggested research appropriate for small colleges and universities, are development of Self-Powered Exploration Devices (SPED), and Miniature Ultra-power Storage Technologies (MUST). The SPED objective is to run a small self-powered mobile device around a small table-top, low-friction track using electrical energy generated by elements of the environment, with no stored power at the start. The energy source can be vibrational, acoustic, biological, chemical, thermal, solar, or any physical characteristic from the natural environment that can generate energy for storage or immediate use. The MUST objective is to run a small device continuously, from environmentally generated power, for an extended period of time, using a miniature capacitor, or battery, technology. A long running device is the objective.

These tasks are suitable for small academic institutions where probable long technology development time trajectories and low levels of focused technology development effort are ideally accommodating for students to mature to convergence with concurrently maturing respective technologies. The SPED and MUST technologies

are designed to merge into a “Game Changing” Development (TRL 3-5) of Smart Dust Motes, partnering with a larger university already making advances in the field.

“Smart Dust Motes” are millimeter-scale self-contained micro-electromechanical devices (MEMS) that include sensors, computational ability, bi-directional wireless communications technology and a power supply. Size development as of about 2007, Hitachi, are tiny dust particle devices with dimensions of about 0.05 x 0.05 mm. This aggregate development, sensing/bi-directional wireless communication, hence “swarming”, is biomimetic. Potential future partnership possibilities are companies and institutions interested in low-bandwidth, low-power wireless mesh networks that transmit data using radio signals.

Finally, DARPA researchers pioneered the area of Dust Motes since the early ‘90s. Top research universities such as Berkeley, MIT, Stanford, etc., have also been active in this field, involving MEMS and the most recent advances in digital circuitry and wireless communication since inception of the idea. The challenges for Smart Dust are to create a package that includes all the elements needed to perform sensory measurements, while also being able to communicate back to a base station to process the data. The “Smart Dust Mote”, which could contain micro-fabricated sensors, optical receivers, passive and active optical transmitters, signal-processing and control circuitry, and power sources, in a MEMS device, is very highly advanced already, relative to someone just getting started. SPED/MUST research is ideal for smaller colleges and universities to gain experience in these areas. This positions them to participate in ultimate Dust Mote development ideal for a partnership arrangement.

Interested NASA directorates are, e.g., HEOMD, and STMD.